Approaches of Educational Technologies of Open Systems

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Open education is considered in the modern context of the society development as a practical way of developing the potential of the individual for purposes related to the construction of possible images of the future, the development and planning of personal growth in it. The methodology, on its basis the structures and technologies of open education are formed, requires a transition from schemes of theoretical and engineering-design thinking that oppose the subject of thinking to its object, to schemes of practical thinking. Recognition of the idea value of the practical thinking leads to a conceptual shift in the organization of educational practices based on the principles of practical interpretation of knowledge, where the element of planning of the education content is not the concept, but the scope or form of knowledge [1].

Open education as a practice of developing the potential of the individual requires a networked and open organization of the educational space, in contrast to education focused on the culture broadcasting. The organizational element of open education is an educational program, not an institution. In this case, the educational program in open educational system is not set in didactic logic, based on a sequential process presentation of the mastering an subject, but in integral logic, that is, with the simultaneous unfolding of all the completeness of practice that represents the mastering object.

At the present time, a new educational industry is being created, including the processes of re-scoping or re-forming knowledge in order to actualize the potential of the individual in education. Modern statistics point out the activation of the processes of formation and capitalization of new global educational brands which are not connected with traditional universities, and attract the audience attention of the open network space [2]. The attendance statistics of open universities demonstrate the high relevance of these resources to students of different nationalities and state affiliation. Modern institutions of open education are developing either as networks of additional education, gradually integrating with the institutions of basic education, or as a system of professional education. The development of such networks requires methodological, logical-epistemological (classical), technological research of the content of educational tasks, possible schemes of transitions and pathes in the educational space, schemes of organization, leadership and management. However, the problem of reorganizing existing educational institutions as spaces for the development of human potential remains very urgent.

Along with the above-mentioned phenomena in the field of open education, a whole range of unique educational directions emerges, possible only within the framework of an open approach to the educational process and forming exclusive human qualities for orientation in extreme situations, creative thinking, record-breaking strategies, creative intuition, abilities to opening (such as institutes of intensive training, educational Game industry, a next generation of professional simulators and trainings, mass trainings, networks and network education, social and territorial educational programs of advanced development, the practice of human development, personnel training and so on). New forms of e-learning and technology are being developed and institutionalized to support the implementation of these models and standards for evaluating and recognizing educational achievements are emerging [3, 4] as a response to the emergence of new educational platforms which are oriented towards a global educational audience.

The noted trends demonstrate the increasing scale of the «exit» process of the training contingent (and other categories of educational services consumers) into global educational networks. The peculiarity of such networks is the educational concentration in the leading educational centers and a impressive increase in the number of students per teacher due to e-learning opportunities. This ensures knowledge from leading professors and experts, access to current and demanded courses for all consumers of educational services.

The purpose of the research carried out by the authors is to describe the application of the principles and technologies of open systems for setting the information infrastructure of science and education as one of the most important fragments of the national information infrastructure and justifying the need for further integration of this infrastructure with the global information infrastructure.

The operations analysis system, optimization theory, probability theory, open system principles, open systems technology, system profile construction are used to solve such problems.

One of the key problems in the field of the open educational space informatization is the effective use of network-wide information and computing resources, which is caused not only by increased hardware and technical system requirements, but also by increased requirements for the applicability, content and personalization of system content.

The research shows that interaction, integration and differentiation of natural-mathematical and technical-technological knowledge generate the problem of exponential growth of scientific knowledge offered for mastering. One of the ways to resolve this problem is to optimize the content of training, carried out through a number of activities, including optimization of the courses structure, in particular, by using a block-modular approach for organising the course content. The informational and technological aspect of pedagogical planning within the block-modular approach framework is connected, first of all, with the revision of the information content of education and significantly affects the formation of the information basis of interactive teaching technologies. Thus, the formalization of the teaching material and the optimization of the information basis structure refers to one of the most difficult and time-consuming problems in the field of e-learning [5].

The analysis of methods for improving the mechanisms for managing the process of interactive learning in the education system allowed the authors to form a general scheme, for which the subject's active actions the in the learning environment is characteristic, including experimental and research activities. In this activity process there is an accumulation of data on the progress and management of the learning process, (the subject acts alternately as a managed and control system), as well as the determination of the parameters of information and computer systems, the determination of optimal forms of the information basis (IS), the development of the typology of information resources of educational material (EM), the basic requirements for them.

During the research it was also revealed that the formation of requirements for the IS block-modular structure in training systems corresponds the main directions for determining specifications and standards for training systems based on software and information technologies. At the same time, it is possible to single out the main directions of modeling and standardization of information-learning systems: architecture and general requirements to the system; models of the student, teacher, their interaction; the development of IS course (educational and methodological content); data and metadata (format of training materials); educational management system.

The authors of the work also suggest to use mathematical formalism to optimize the information structure of the content (knowledge) of automated learning systems as a mechanism for efficient management of the distribution of information flows of knowledge in open systems based on the Grid computing knowledge principles.

The main idea of optimizing the processes of knowledge redistribution in open learning systems is to represent distributed information flows of knowledge in the form of controlled processes and is based on the decomposition of these processes into separate modules of the mobile and flexible structure formed by the system itself depending on some optimality (efficiency) criterion [5, 6 , 7].

To determine the optimal characteristics of the processes of controlled knowledge and to analyze the modular structure of these processes, some additional assumptions were made in the work, in particular:

- the elemental operational composition of the process is quite uniform, which allows to split it into modules of separate procedures (parts of knowledge) of an arbitrary volume;
- the probability of an effective implementation of the process is proportionally dependent on the operations volume in the process;
- as a criterion for the decomposition effectiveness of distributed knowledge flows, the total labor intensity of the process as the main characteristic of the educational process was chosen.

In the research, the hypothesis about the exponential nature of the dependence of the probability of effective realization of the process on the volume of operations in the composition of this process, often used in the practice of process management, was used [8]. In this case, the probability of an effective process execution can be represented in the form:

$$p(\Theta) = \exp(-\lambda\Theta), \quad (1)$$

where Θ – the amount of time for operations execution for a certain process is (unit of time);

λ (1/ unit of time) – is a constant representing the rate of decrease in the probability of an effective completion of the process, depending on the volume of operations in this process.

The value of λ depends on the type (content, structure, etc.) of operations in the process and can be evaluated expertly or experimentally based on experience with a particular process.

With a large number of experiments, the problem of estimating the parameter λ can be solved using the method of least squares and is:

$$\lambda = -\frac{\sum_{i=1}^{m} \ln p_i \Theta_i}{\sum_{i=1}^{m} \Theta_i^2}, \quad (2)$$

where m – the number of experiments performed to modify the structure of the process;

$\Theta_1,...,\Theta_m$ – the volume of operations included in the process (unit of time);

$p_1,\ldots, p_m$. – probability of successful completion of the process.

In the author's research, the use of standard methods of probability theory was proposed to evaluate the reliability of the obtained results [31]. In particular, to describe the process of managing distributed knowledge flows in an open interactive education system, a Markov model of dynamical systems is proposed [8].

In the proposed model for managing distributed knowledge flows in an open system, a number of states and probabilities of system transitions from one state to another are identified:

S_1 - implementation of the educational process;

S_2 - interactive impact (treatment) during the implementation of the educational process (for example, inclusion of additional information materials in the process, use of consultations during the process; the «teacher-learner» feedback and response to this feedback, decision-making under alternative implementation scenarios process, etc.) and associated with this impact the need for dynamic adjustment of the educational process;

S_3 - evaluation of the effectiveness of the educational process in an open system;

S_4 - completion (implementation) of the educational process in an open system;

r - probability of interactive impact (treatment);

s - probability of transition to evaluation activities for the educational process in an open system;

p - probability of effective performance of evaluation activities and completion of the educational process in an open system;

q - probability of inefficient implementation of evaluation activities and re-implementation of the educational process in an open system to achieve the ultimate goal of training.

Using the apparatus of matrix algebra, taking into account the fulfillment of the obvious relations $r+s=1$, $p+q=1$, the authors obtained estimates of the average number of attempts to implement the educational process in an open system in the form of the average number of process stays, respectively, in the states $\{S_1, ..., S_4\}$ when starting from the state S_1:

$$n_1 = \frac{1}{s \cdot p}; \quad n_2 = \frac{r}{s \cdot p}; \quad n_3 = \frac{1}{p}, \tag{3}$$

where n_1 – the average number of attempts to implement the educational process in an open system;

n_2 – the average number of attempts of interactive influences during the implementation of the educational process in an open system;

n_3 – the average number of attempts to perform evaluation activities for the educational process in an open system.

At the same time, the total complexity of the educational process in the open system, taking into account relations (3), can be determined by the following expression:

$$R = n_1 \cdot \Theta + n_2 \cdot \Theta_1 + n_3 \cdot \Theta_2 = \frac{1}{p}\left[\frac{1-q}{s}(\Theta - r\Theta_{1)} + \Theta_2\right], \tag{4}$$

where Θ – the complexity of implementing the educational process in an open system;

Θ_1 – the complexity of interactive impacts when implementing an educational process in an open system (state S_2);

Θ_2 – the complexity of the implementation of evaluation activities for the educational process in an open system (state S_3).

To evaluate the parameters of the overall complexity of implementing the educational process in an open system with the aim of optimally redistributing educational content, the authors suggest an approach based on the probabilistic characteristics of distributed dynamic online education systems. In particular, a simplified numerical evaluation of the total labor intensity of the educational process was justified:

$$R = e^{\lambda \Theta}(k\Theta + m), \tag{5}$$

where Θ (unit of time) – the total volume of operations (actions) in the educational process;

λ (1/ unit of time) – the rate of decrease in the probability of an effective completion of the process;

k (unit of time) – total costs for the implementation of the educational process;

m (unit of time) – the work complexity of the implementation of evaluation training activities and not depending on the volume of the service (operation).

The structure optimization of the educational process in an open learning system is considered by the authors as a task of decomposition of a separate

educational process with a total time of operations Θ units time for n procedural educational modules, each of which has a volume of Θi units time when the relation $\Theta = \sum_{i=1}^{n} \Theta_i$.

Thus, the task of optimizing the block-modular structure of informational educational and methodological material in an automated educational system, the approach for solving it was considered by the authors of work in previous studies, with some additional limitations can be used to improve the management efficiency of the distribution of knowledge flows in open learning systems on the basis of the optimal re-arrangement of information «portions» of the total system content at each current time of learning and taking into account the state of the system and the requirements for learning outcomes.

As part of the solution of the issues of standardization of open education systems, the authors propose an architecture model for component-based computer-aided instruction (CAI) systems, taking into account the needs of Intelligent Learning Environment (ILE) software and Intelligent Tutoring Systems (ITS). In this case, open training courses models are considered as objects for unifying the requirements for their structure, the sequence of presentation of training materials, packaging courses in unique shells. In the framework of this direction, the authors propose a standard for the language of interchange for computer-aided learning systems (SIT), as a standard for describing the language of specifications and the environment for sessions managing in open-type information-learning systems, with mechanisms of incorporating educational resources and supporting individual education. Standardization on SIT base allows using unified methods of packaging the contents of training courses, creating collections of replicable training components, setting up flexible electronic communications environments, which improves the quality of interactive e-learning.

Within the framework of the researches carried out by the authors, the creation of an electronic educational environment (EEE) based on cloud technologies aimed at implementing world standards in the field of e-learning is also substantiated [10]. At the same time, information is systematized in studies, and experience is analyzed in the field of e-learning of educational organizations, as well as organizations interested in the development of education and educational technologies, including start-ups that provide sites and technologies that ensure the introduction and distribution of e-learning technologies.

Based on the above mentioned, the authors justify the understanding of the term of the open education system not in the form of a single technical platform and a set of electronic resources placed on it, but as a set of standards / norms that ensure the use of educational content placed on different platforms (incl. international), in the network space of education system.

The analysis of the conditions for the EEE implementation in Russian universities shows that such an environment is realized through partnership and involvement of the main stakeholders: the state, universities, business (employers), students. In the EEE concept, the Ministry of Education and Science of the Russian

Federation implements a number of functions: providing a communication platform for launching projects for the development and use of electronic content and the introduction of modern educational technologies; provides improvement of the legal framework for e-learning technologies; implements mechanisms to stimulate demand and the need of electronic content. In addition, the analysis of practical experience in the implementation of e-learning in Russian universities has shown that the electronic environment is created on the basis of mechanisms that promote students mobility, encourage them to choose quality courses and educational programs, support market competition mechanisms, and drop out «high-education providers» of low-quality content.

Taking into account the above conditions, the authors identified a number of priority areas of work that contribute to the development of an open electronic educational environment, in particular, the development of standards for educational platforms in the electronic environment that provide the possibility of a network form for the implementation of educational programs; the development of incentive mechanisms for electronic content developers; the development of mechanisms for motivating corporations to participate actively in educational development projects; the development of tools to stimulate the active position of students and listeners in the selection of quality electronic content and educational programs; the implementation of «transfer of educational technologies» strategy, namely, the use of opportunities for interaction with the world's educational content providers in order to adopt technologies and develop the competencies of Russian content providers; cooperation with the leading players of the educational market for a quick access to the global educational space; the development of Russian brands of content providers and opened educational platforms.

The large-scale application of educational technologies of open systems, researched by the authors, contributes to the development of an integrated information environment of science and education, and also improves the infrastructure of society as a whole and creates prerequisites for the all-round development of the individual.

Bibliographic references

1. Mullen J., Byun C., Gadepally V., Samsi S., Reuther A., Kepner J. Learning by doing, high performance computing education in the mooc era // Journal of Parallel and Distributed Computing. 2017. T. 105. C. 105-115.

2. Ivaniushin D.A., Lyamin A.V., Kopylov D.S. Assessment of outcomes in collaborative project-based learning in online courses // Smart Innovation, Systems and Technologies. 2016. T. 59. C. 351-361.

3. Stuchlíková L., Kósa A. Massive open online courses - challenges and solutions in engineering education // В сборнике: ICETA 2013 - 11th IEEE International Conference on Emerging elearning Technologies and Applications, Proceedings 2013. C. 359-364.

4. Berezytskyi M.M., Oleksyuk V.P. Massive open online courses as a stage in the development of e-learning // Information technologies and teaching methods. 2016. T. 56. № 6. P. 51-63.

5. *Korpacheva, L.N. Optimization of information basis formation in interactive adaptive-learning systems. Thesis for the degree of Candidate of Technical Sciences / L.N. Korpachev. - Krasnoyarsk, 2006.*

6. *Stupina A.A. Optimization of management in interactive learning systems: monograpyh / A.A. Stupina, M.V. Karasev, L.N. Korpacheva // - Krasnoyarsk: Sib. feder. Univ., 2014. - 156 p.*

7. *Stupina A.A., Korpacheva L.N., Kuzmich R.I., Fedorova A.V., Ezhemanskaya S.N. Synthesis of the optimal structure of the information basis for interactive learning systems // Modern problems of science and education. - 2012. - № 6. URL: https://science-education.ru/en/article/view?id=7411*

8. *Gorobets G.S. Theory of Probability, Mathematical Statistics and Elements of Random Processes /G.S. Gorobets. - Moscow: KD Librocom, 2013. - 232 p.*

9. *Korpacheva L.N., Bogdanova O.V., Stupina A.A., Yuronen E.A., Fedorova A.V., Ezhemanskaya S.N., Mandrichko T.M. Principles of open systems and development of information and teaching technologies // Modern problems of science and education. - 2013. - № 5. URL: https://science-education.ru/en/article/view?id=10253*

10. *Wang H., Li Y., Hu X., Yang Y., Meng Z., Chang K.M. Using eeg to improve massive open online courses feedback interaction // In: CEUR Workshop Proceedings 16. 2013. P. 59-66.*